

# **Preliminary analysis of environmental impacts of video rentals in the U.S.**

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Flexplay Technologies asked me to conduct an independent analysis of environmental impacts of video rentals in the U.S., for purposes of assessing the potential effects of Flexplay DVDs on those environmental impacts. The standard methodology for conducting complete analyses of environmental impacts is called Life Cycle Assessment (LCA), the framework for which is summarized in ISO standards 14040, 14041, and 14042. Such an analysis involves defining two or more technologies that deliver equivalent service (e.g., reusable, rented DVDs and Flexplay DVDs that are thrown out after each use), and tracing each and every step in the process of manufacturing and using the devices that deliver equivalent service. These steps include the extraction, refining, and processing of the raw materials to produce each product, as well as the disposal of any waste products at the end of the product life.

Creating a comprehensive LCA, which is always a difficult and complex endeavor, was not possible in the time allotted. Instead, I focused on the two “first-order” environmental impacts related to Flexplay DVDs: The increased solid waste disposal from using disposable DVDs instead of reusable ones, and the air pollution reductions associated with fewer trips to the video store when using Flexplay DVDs. Table 1 shows the results of those calculations, and the footnotes explain the methodology and assumptions.

If Flexplay DVDs comprised 10% of all video rentals in the U.S., they would eliminate 10% of all discretionary return trips to drop off movies. They might also reduce discretionary trips to pick up movies if the ease and low cost of distributing Flexplay DVDs makes them widely available in retail outlets that are more widely distributed than video stores, but we ignore this effect here. The key implications of eliminating these trips are as follows:

- Adoption of Flexplay at 10% of all rentals would save 47 million gallons of gasoline every year in the U.S.
- Adoption of Flexplay at 10% of all rentals would eliminate 110,000 metric tons of carbon emissions, 700 tons of hydrocarbons, and 1,000 tons of nitrogen oxides every year in the U.S.
- These emissions savings would be equivalent in their effects to removing 82,000 passenger car and light trucks from the road permanently.

Use of Flexplay DVDs for 10% of all video rentals in the U.S. implies that 350 million additional DVDs would be manufactured and thrown away each year. The solid waste implications of this increased use of Flexplay DVDs are as follows:

- Adoption of Flexplay at 10% of all rentals would result in an additional 5,600 metric tons of solid waste each year in the U.S. The total volume of these DVDs is about 4,300 cubic meters, or the same volume as a cube 16 meters (52 feet) on a side.
- Each household that used Flexplay DVDs for 33 rentals per year (the average number of rentals per household in the U.S.) would throw out additional materials (in the form of DVDs) that when crushed or melted add up to a cube about 3 inches on a side and weigh about 1.2 lbs. This mass of materials represents about 0.05% of annual residential solid waste from a typical U.S. household.
- Adoption of Flexplay at 10% of all rentals would increase the solid waste stream at a rate equivalent to adding another 4900 households in the U.S.

There are many uncertainties in any calculations of this type, but my own view is that the resulting gasoline and emissions savings are large and important compared to the associated increase in solid waste generated. For example, polycarbonate is made from petroleum products that are similar to gasoline. The mass of gasoline saved from avoided vehicle trips is about 22 times the mass of polycarbonate that would go into the solid waste stream if Flexplay were widely adopted. The exact materials efficiency of converting petroleum products to plastics depends on a variety of factors, but a factor of 22 should account for the wasted plastics several times over, resulting in an overall reduction of resource use.

There are other issues to consider in a comparative assessment of these technologies, including the value of the time saved from reduced driving, the value of the gasoline savings, the indirect emissions and other environmental impacts associated with manufacturing and disposal of DVDs, and the costs of disposal of DVDs compared to reusable DVDs. In addition, substantial increases in the use of DVDs may result in new methods to recycle them, mitigating some of the solid waste impacts of this technology. These issues were not included in this study because of time constraints, but are worthy topics of further research. It is not clear how incorporating these factors would affect the results, because some of these factors push the results in one direction, and others push them in the other direction.

### **Author's biography**

Jonathan Koomey is a Staff Scientist at the Lawrence Berkeley National Laboratory (LBNL) and the leader of LBNL's End-use Forecasting Group. He holds M.S. and Ph.D. degrees from the Energy and Resources Group at the University of California at Berkeley, and an A.B. (Cum Laude) in History of Science from Harvard University. He is the co-author of seven books and author or co-author of more than one hundred articles and reports on energy conservation technology, energy economics, energy & environmental policy, environmental externalities, and global climate change. His seventh book, titled *Turning Numbers into Knowledge: Mastering the Art of Problem Solving*, is in production and will be published by Analytics Press in early 2001. His group's work supporting the U.S. Environmental Protection Agency and the U.S. Department of Energy can be accessed on-line at <http://enduse.lbl.gov>. This memo can be downloaded in PDF format at <http://enduse.lbl.gov/Projects/InfoTech.html>.

**Table 1: Some key information about the environmental impacts of video rentals in the U.S.**

	Per household (HH)				Total US			
	Pick up movies	Drop off movies	Units	Notes	Pick up movies	Drop off movies	Units	Notes
Number of rentals	33	33	Rentals per household/yr	1	3.5	3.5	Billion rentals/yr	15
Average number of rentals per trip to the store	1.5	1.5	Rentals per trip	2				
Percent of trips solely for movies	80%	50%	%	3				
Number of trips solely for movies	17.6	11	Trips per HH/yr	4	1.8	1.2	Billions of trips/yr	15
Round trip distance from home to video store	8	8	Miles/trip	5				
Travel associated with trips solely for movies	141	88	Miles/HH/yr	6	15	9.2	Billion miles/yr	15
Gasoline use associated with trips solely for movies	7.1	4.5	Gallons/HH/yr	7	0.75	0.47	Billion gallons/yr	15
Carbon emitted from trips solely for movies	17	11	Kilograms carbon/HH/yr	8	1.82	1.14	Million metric tons carbon/yr	15
Hydrocarbons (HC) emitted from trips solely for movies	113	70	Grams HC/HH/yr	9	12	7.4	Thousand metric tons HC/yr	15
Nitrogen oxides (NO <sub>x</sub> ) emitted from trips solely for movies	169	106	Grams NO <sub>x</sub> /HH/yr	10	18	11	Thousand metric tons NO <sub>x</sub> /yr	15
Mass of disposable DVDs if they comprise 10% of all rentals		0.054	Kilograms/HH/yr	11		5.6	Thousand metric tons/yr	15
Volume of disposable DVDs if they comprise 10% of all rentals		41	Cubic centimeters/HH/yr	12		4.3	Thousand cubic meters	15
Carbon emissions in 2000 from passenger cars & light trucks		2764	Kilograms carbon/HH/yr	13		290	Million metric tons carbon/yr	13
Total municipal solid waste from the residential sector in 2000		1153	Kilograms/HH/yr	14		121	Million metric tons/yr	15

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**Notes to Table 1 (Contact JGKoomey@lbl.gov, <http://enduse.lbl.gov/projects/infotech.html>, 510/486-5974.)**

1. The sample of 21 video store customers surveyed in Burlington, MA on June 4th, 2000 (hereafter called "Burlington survey") had a higher total of about 50 movies rented per year.  
I used a lower estimate of 33 videos per household per year because the Burlington survey sample included only people who rent videos (because it was conducted in a video rental store).  
This estimate results in a slightly lower total number of rentals than the roughly 4 billion rentals per year shown in Understanding & Solutions. 1999. Home Video Watch: Home Video Market Report USA. Dunstable, Bedfordshire, UK: Understanding & Solutions, U&S@undansol.co.uk. November.
2. Burlington survey showed 1.24 movies per trip.
3. Burlington survey showed 83% of video-related trips were solely for pick up and 47% were solely for drop off.
4. For now, we ignore trips to the video store that include other errands, because the net incremental travel distance is difficult to estimate.
5. Sample in the Burlington survey is 8.6 miles round trip (RT), while Brynjolfsson and Smith paper indicates slightly more than 10 miles RT for CDs and books, on average.  
Brynjolfsson, E. and M. Smith, "Frictionless Commerce? A Comparison of Internet and Conventional Retailers", Management Science, Vol. 46, No. 4, April, 2000.
6. Miles per trip times trips per household (HH) per year.
7. Calculated as miles/HH/yr divided by average fuel efficiency of passenger cars and light trucks (19.7 miles per gallon in 1997, from DOT's National Transportation Statistics, <http://www.bts.gov/ntda/nts/>). This fuel efficiency assumption implies that the average trip to the video store has the same ratio of highway to city driving as for all trips in the US.  
If trips to the video store are more commonly city driving than the average of all US trips, the fuel efficiency would be lower, implying greater gasoline use and associated emissions.
8. Carbon emissions calculated based on an emissions factor of 5.34 lbs of carbon per gallon of gasoline, from EIA report Emissions of Greenhouse Gases in the U.S. (<http://www.eia.doe.gov>)
9. Emissions of Hydrocarbons based on a typical stock emissions factor of 0.8 g/mile, from Marc Ross, Professor of physics at University of Michigan, Personal communication, June 7, 2000.
10. Emissions of nitrogen oxides based on a typical stock emissions factor of 1.2 g/mile, from Marc Ross, Professor of physics at University of Michigan, Personal communication, June 7, 2000.
11. Assumes 1 DVD has a volume of 12.5 cubic cm, and a density of polycarbonate of 1.3 g/cubic cm, yielding a mass per DVD of 16.3 g. The estimate of kg/HH/yr is an average over all HHs.
12. Assumes DVD density of 1.3 grams/cubic cm. <http://secure.matls.com/polycarbonate.htm> shows typical polycarbonate densities of about 1.2-1.3 g/cubic cm.  
I choose 1.3 g/cubic cm because there is a small amount of metal in the DVD that is denser than polycarbonate. The estimate of cubic cm/HH/yr is an average over all HHs.
13. Total year 1997 carbon emissions for passenger cars & light trucks from US EPA. 1999. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1997. Washington, DC: U.S. Environmental Protection Agency. EPA 236-R-99-003. April. Totals adjusted upwards by 7.5% to reflect growth in transportation sector carbon emissions 1997-2000, per AEO 2000 (See note 14). Per household numbers derived by dividing totals by 105 million households.
14. Total year 2000 US solid waste from EPA's Municipal Solid Waste Factbook <http://www.epa.gov/epaoswer/non-hw/muncpl/factbook/> 222 million short tons per year  
The residential fraction of this solid waste is about 60% based on <http://www.epa.gov/epaoswer/non-hw/muncpl/msw98.htm> (the rest, 40%, is from the commercial sector).
15. Total US numbers represent per household numbers times 105 million households (year 2000, from EIA's Annual Energy Outlook 2000, <http://www.eia.doe.gov>).